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National Eutrophication Survey, Corvallis, Oreg

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT

ON

LAKE ASHTABULA

BARNES AND GRIGGS COUNTIES

NORTH DAKOTA

EPA REGION VIII

WORKING PAPER No. 565

WITH THE COOPERATION OF THE

NORTH DAKOTA STATE DEPARTMENT OF HEALTH

AND THE

NORTH DAKOTA NATIONAL GUARD

SEPTEMBER, 1976

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the North Dakota State Department of Health for professional involvement, to the North Dakota National Guard for conducting the tributary sampling phase of the Survey, and to those North Dakota wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

Norman L. Peterson, Director, and the staff of the Division of Water Supply and Pollution Control of the Department of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

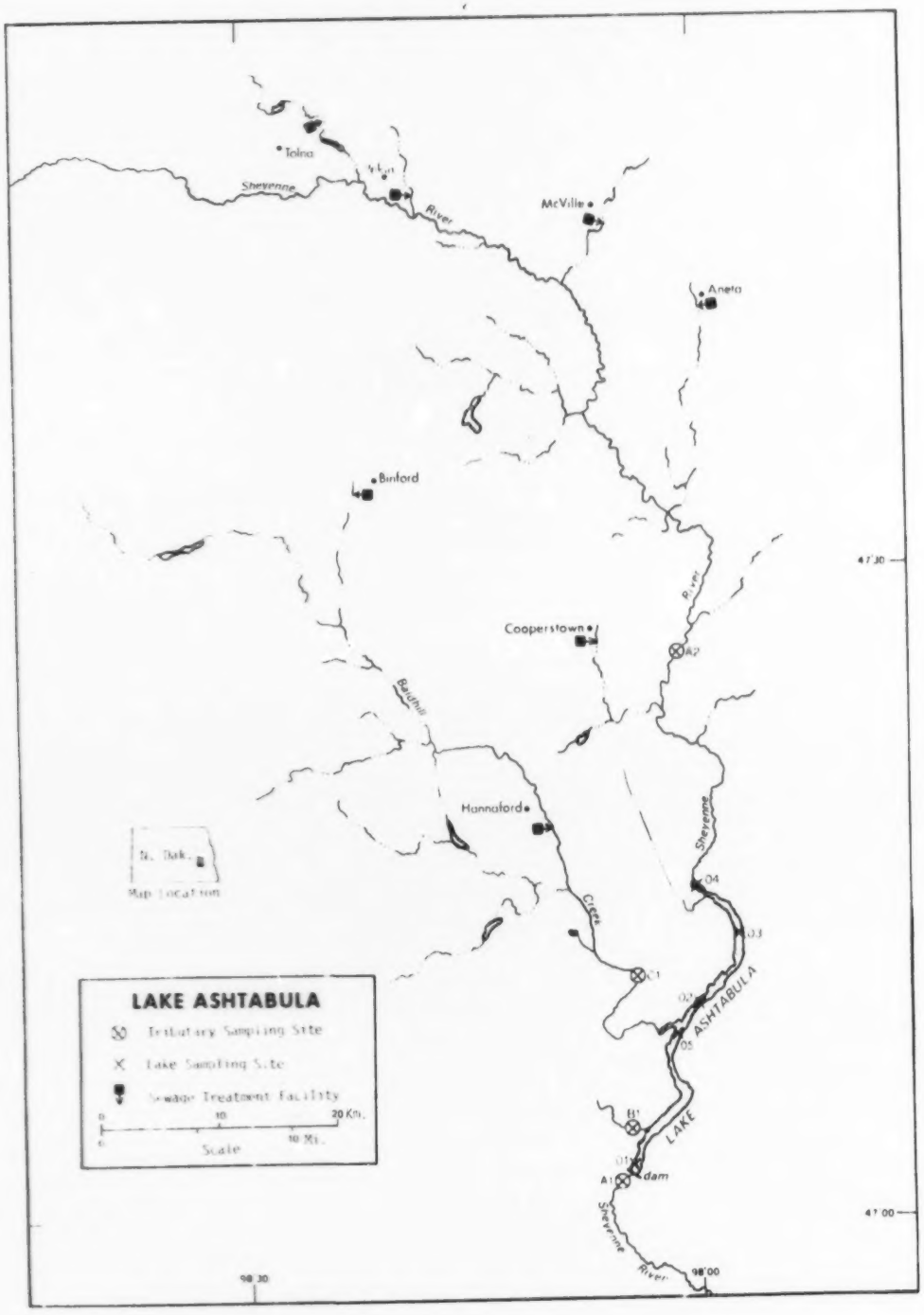
Major General LaClair A. Melhouse, the Adjutant General of North Dakota, and Project Officer Colonel Irvin M. Sande, who directed the volunteer efforts of the North Dakota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES AND RESERVOIRS

STATE OF NORTH DAKOTA

NAME	COUNTY
Ashtabula	Barnes, Griggs
Audubon	McLean
Brush	McLean
Darling	Renville, Ward
Devils	Benson, Ramsey
Jamestown	Stutsman
LaMoure	LaMoure
Matejcek	Walsh
Metigoshe	Bottineau
Pelican	Bottineau
Sakakawea	Dunn, McKenzie, McLean, Mercer, Mountrail, Williams
Spiritwood	Stutsman
Sweet Briar	Morton
Whitman	Nelson, Walsh


Tolna
Sheyenne
River
McVille
Aneta
Binford
Cooperstown
A2
Baldhill
Creek
Hannaford
N. Dak.
Map Location
Sheyenne
River
LAKE
ASHTABULA
dam
A1
LAKE ASHTABULA
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0
10
20 Km.
0
10 Mi.
Scale
47°30
47°00
98°30
98°00

LAKE ASHTABULA

STORET NO. 3801

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate Lake Ashtabula is eutrophic. It ranked ninth in overall trophic quality when the 14 North Dakota lakes sampled in 1974 were compared using a combination of six water quality parameters*. Nine lakes had less and one had the same median total phosphorus, eight had less median dissolved orthophosphorus, six had less median inorganic nitrogen, 12 had less mean chlorophyll a, and 11 had greater mean Secchi disc transparency.

Survey limnologists noted heavy algal blooms and extensive beds of submerged macrophytes during sampling visits. This lake has a history of excessive aquatic vegetation and algal blooms, periodic depletion of dissolved oxygen, and fish kills (Peterson, 1975).

B. Rate-Limiting Nutrient:

The algal assay results indicate that Lake Ashtabula was limited by nitrogen at the times samples were collected (04/30/74 and 09/17/74). The lake data indicate nitrogen limitation at all sampling times.

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* See Appendix A.

C. Nutrient Controllability:

1. Point sources--Listed point sources contributed 6.3% of the total phosphorus input to Lake Ashtabula during the sampling year. The wastewater treatment plants at Cooperstown and Hannaford contributed an estimated 5.3% and 0.9% of the total, respectively. Septic tanks serving lakeshore residences, parks, and campsites were estimated to have contributed 0.1%. In addition, there are a number of small wastewater treatment facilities of unknown significance which discharge in this drainage basin beyond the 40-kilometer limit of the Survey* (see map, page v).

The present phosphorus loading of 1.46 g/m^2/year is over three times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 13). Minimization of both point and non-point sources of phosphorus probably would be necessary to improve the trophic condition of the lake.

2. Non-point sources--Non-point sources contributed 93.7% of the total phosphorus load during the sampling year. The Sheyenne River contributed 81.1%, Baldhill Creek contributed 7.4%, and the ungaged minor tributaries and immediate drainage contributed an estimated 4.1%.

Land use in the Lake Ashtabula drainage is predominantly agricultural (Peterson, 1974), and reduction of phosphorus resulting

* See Working Paper No. 175, "...Survey Methods, 1973-1976".

from such use may be difficult. Additional investigation is needed to determine the contribution and controllability of phosphorus resulting from land-use practices in the drainage basin.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 21.98 kilometers^2.
2. Mean depth: 4.0 meters.
3. Maximum depth: 13.7 meters.
4. Volume: 87.920 x 10^6 m^3.
5. Mean hydraulic retention time: 304 days (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Sheyenne River	3,289.3	2.900
Baldhill Creek	986.8	0.407
Minor tributaries & immediate drainage -	648.8	0.430
Totals	4,924.9	3.737

2. Outlet -

Sheyenne River	4,946.9**	3.350

C. Precipitation***:

1. Year of sampling: 54.7 centimeters.
2. Mean annual: 49.6 centimeters.

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† Table of metric conversions--Appendix B.
†† Henegar, 1975.
* For limits of accuracy, see Working Paper No. 175.
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Lake Ashtabula was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from four stations on the lake; station 4 was sampled only in April, and station 5 was sampled in July and September (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the April and September visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 8.2 meters at station 1, 5.2 meters at station 2, 5.5 meters at station 3, near-surface only at station 4, and 6.1 meters at station 5.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR LAKE ASTABULA
STORET CODE 3801

	1ST SAMPLING (4/30/74) 4 SITES			2ND SAMPLING (7/17/74) 4 SITES			3RD SAMPLING (9/17/74) 4 SITES		
PARAMETER	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	5.9 - 12.3	9.5	11.6	23.4 - 24.7	24.2	24.2	14.0 - 15.3	14.6	14.5
DISS OXY (MG/L)	8.4 - 10.2	9.2	8.8	4.4 - 9.4	6.2	5.8	8.8 - 11.4	10.2	10.0
CNDCTVY (MCROMO)	265. - 442.	318.	308.	698. - 867.	743.	713.	541. - 633.	579.	567.
PH (STAND UNITS)	7.6 - 8.1	7.8	7.7	8.4 - 8.7	8.5	8.5	8.8 - 9.0	8.9	8.9
TOT ALK (MG/L)	104. - 163.	134.	138.	244. - 328.	270.	259.	310. - 515.	438.	440.
TOT P (MG/L)	0.236 - 0.261	0.245	0.244	0.283 - 0.477	0.339	0.318	0.196 - 0.286	0.228	0.216
ORTHO P (MG/L)	0.117 - 0.170	0.140	0.142	0.273 - 0.317	0.286	0.279	0.058 - 0.220	0.122	0.112
NO2+NO3 (MG/L)	0.220 - 1.020	0.634	0.610	0.040 - 0.100	0.066	0.065	0.020 - 0.030	0.021	0.020
AMMONIA (MG/L)	0.060 - 0.410	0.200	0.095	0.040 - 0.190	0.117	0.110	0.030 - 0.060	0.042	0.040
KJEL N (MG/L)	1.200 - 1.900	1.480	1.450	0.900 - 1.600	1.250	1.200	1.000 - 3.500	1.818	1.700
INORG N (MG/L)	0.320 - 1.430	0.834	0.695	0.110 - 0.290	0.184	0.165	0.050 - 0.090	0.063	0.060
TOTAL N (MG/L)	1.610 - 2.920	2.114	2.110	0.970 - 1.670	1.316	1.265	1.020 - 3.520	1.839	1.720
CHLRPYL A (UG/L)	5.4 - 52.5	29.4	29.8	16.1 - 60.9	39.7	40.9	17.1 - 78.3	53.6	59.5
SECCHI (METERS)	0.3 - 0.4	0.4	0.4	0.9 - 1.2	1.0	0.9	0.5 - 1.2	0.7	0.6

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/30/74	1. Cyclotella sp.	24,617
	2. Chroomonas sp.	222
	3. Cryptomonas sp.	148
	4. Ankistrodesmus sp.	111
	5. Chlamydomonas sp.	74
	Other genera	221
	Total	25,393
07/17/74	1. Melosira sp.	2,400
	2. Aphanizomenon sp.	304
	3. Fragilaria sp.	213
	4. Glenodinium sp.	182
	5. Chroomonas sp.	61
	Other genera	789
	Total	3,949
09/17/74	1. Aphanizomenon sp.	9,136
	2. Melosira sp.	4,637
	3. Anabaena sp.	446
	4. Fragilaria sp.	412
	5. Flagellates	343
	Other genera	584
	Total	15,558

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
04/30/74	1	5.4
	2	21.5
	3	52.5
	4	38.1
	5	-
07/17/74	1	16.1
	2	52.6
	3	60.9
	4	-
	5	29.2
09/17/74	1	17.1
	2	61.4
	3	78.3
	4	-
	5	57.6

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. April sample (stations 1, 2, 3, & 4) -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.135	0.702	19.6
0.050 P	0.185	0.702	17.7
0.050 P + 1.0 N	0.185	1.702	41.7
1.0 N	0.135	1.702	38.0

b. September sample (stations 1, 2, 3, & 5) -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.140	0.372	12.9
0.050 P	0.190	0.372	13.9
0.050 P + 1.0 N	0.190	1.372	39.4
1.0 N	0.140	1.372	37.4

2. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that the potential primary productivity of Lake Ashtabula was very high at the times the samples were collected.

A significant increase in yield occurred when only nitrogen was added but not when phosphorus only was added. These results indicate nitrogen limitation.

The lake data indicate nitrogen limitation all three sampling times (the mean inorganic nitrogen to orthophosphorus ratios were 6 to 1 or less, and nitrogen limitation would be expected).

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the North Dakota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of April and May when two samples were collected. Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the North Dakota District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads at station C-1, in kg/km^2/year, and multiplying by the ZZ area in km^2.

The operator of the Cooperstown treatment plant provided monthly effluent samples. However, corresponding flow data were not available; nutrient loads from this source, as well as those from the Hannaford facility, were estimated at 1.134 kg P and 3.401 kg N/capita/year, and flows were estimated at 0.3785 m^3/day.

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* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Cooperstown†	1,485	stab. pond	562.1	Dry Run/Sheyenne River
Hannaford*	255	stab. pond	96.5	Baldhill Creek

In addition, a number of other small wastewater treatment facilities in the Lake Ashtabula drainage basin serve a combined population of 1,568 (see map, page v). These sources are not listed on the following pages because they are well beyond the 40-kilometer limit of the Survey**.

2. Known industrial - None

† Treatment plant questionnaire.
* Anonymous, 1971.
** See Working Paper No. 175.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Sheyenne River	25,980	81.1
Baldhill Creek	2,360	7.4
b. Minor tributaries & immediate drainage (non-point load) -	1,300	4.1
c. Known municipal STP's -		
Cooperstown	1,685	5.3
Hannaford	290	0.9
d. Septic tanks* -	35	0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	385	1.1
Total	32,035	100.0

2. Outputs -

Lake outlet - Sheyenne River 25,825

3. Net annual P accumulation - 6,210 kg.

* Estimate based on 6 parks, 2 campgrounds, and 67 dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Sheyenne River	228,070	75.3
Baldhill Creek	26,565	8.8
b. Minor tributaries & immediate drainage (non-point load) -	17,520	5.8
c. Known municipal STP's -		
Cooperstown	5,050	1.7
Hannaford	865	0.3
d. Septic tanks* -	1,065	0.3
e. Known industrial - None	-	-
f. Direct precipitation** -	23,730	7.8
Total	302,865	100.0

2. Outputs -

Lake outlet - Sheyenne River 243,675

3. Net annual N accumulation - 59,190 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Sheyenne River	8	69
Baldhill Creek	2	27

* Estimate based on 6 parks, 2 campgrounds, and 67 dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	1.46	0.28	13.8	2.7

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Ashtabula:	
"Dangerous" (eutrophic loading)	0.44
"Permissible" (oligotrophic loading)	0.22

V. LITERATURE REVIEWED

Anonymous, 1971. Inventory of municipal waste facilities. EPA Publ. OWP-1, vol. 8, Wash., DC.

Henegar, Dale, 1975. Personal communication (lake morphometry). ND Game & Fish Dept., Bismarck.

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_____, 1975. Personal communication (North Dakota lake classification). ND Dept. of Health, Bismarck.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	MEAN CHLORA	15- MIN DO	MEDIAN DISS ORTHO P
3801	LAKE ASHTABULA	0.260	0.160	472.250	40.892	10.600	0.170
3802	LAKE AUDUBON	0.047	0.220	446.222	11.322	11.000	0.015
3803	BRUSH LAKE	0.066	0.095	449.143	29.114	9.000	0.010
3804	LAKE DARLING	0.274	0.250	466.750	60.075	11.600	0.180
3805	DEVILS LAKE	0.630	0.140	449.333	38.508	14.600	0.469
3806	JAMESTOWN RESERVOIR	0.144	0.365	438.667	19.400	8.800	0.078
3807	LAKE LA MOURE	0.438	0.380	421.400	19.720	15.000	0.290
3808	MATEJCEK LAKE	0.228	0.440	475.167	2.683	14.400	0.179
3809	LAKE METIGOSHE	0.032	0.080	389.167	10.367	9.000	0.010
3811	PELICAN LAKE	0.034	0.070	364.500	10.950	12.800	0.006
3812	LAKE SAKAKAWEA (GARRISON	0.016	0.150	408.733	6.883	10.800	0.007
3813	SPIRIT WOOD LAKE	0.156	0.290	417.833	34.667	15.000	0.082
3814	SWEET BRIAR RESERVOIR	0.092	0.090	440.800	39.000	8.800	0.031
3815	WHITMAN LAKE	0.260	0.260	478.333	27.067	9.200	0.185

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3801	LAKE ASHTABULA	27 (3)	54 (7)	15 (2)	8 (1)	62 (8)	38 (5)	204
3802	LAKE AUDUBON	69 (9)	46 (6)	46 (6)	69 (9)	46 (6)	69 (9)	345
3803	BRUSH LAKE	77 (10)	77 (10)	38 (5)	38 (5)	81 (10)	81 (10)	392
3804	LAKE JAHLING	15 (2)	38 (5)	23 (3)	0 (0)	38 (5)	23 (3)	137
3805	DEVILS LAKE	0 (0)	69 (9)	31 (4)	23 (3)	15 (2)	0 (0)	138
3806	JAMESTOWN RESERVOIR	54 (7)	15 (2)	62 (8)	62 (8)	96 (12)	54 (7)	343
3807	LAKE LA MOURE	8 (1)	8 (1)	69 (9)	54 (7)	4 (0)	8 (1)	151
3808	MATEJCEK LAKE	38 (5)	0 (0)	8 (1)	100 (13)	23 (3)	31 (4)	200
3809	LAKE METIGOSHE	92 (12)	92 (12)	92 (12)	85 (11)	81 (10)	81 (10)	523
3811	PELICAN LAKE	85 (11)	100 (13)	100 (13)	77 (10)	31 (4)	100 (13)	493
3812	LAKE SAKAKAWEA (GARRISON	100 (13)	62 (8)	85 (11)	92 (12)	54 (7)	92 (12)	485
3813	SPIRIT WOOD LAKE	46 (6)	23 (3)	77 (10)	31 (4)	4 (0)	46 (6)	227
3814	SWEET BRIAR RESERVOIR	62 (8)	85 (11)	54 (7)	15 (2)	96 (12)	62 (8)	374
3815	WHITMAN LAKE	27 (3)	31 (4)	0 (0)	46 (6)	69 (9)	15 (2)	188

LAKES RANKED BY INDEX NO.

RANK	LAKE CODE	LAKE NAME	INDEX NO.
1	3H09	LAKE METIGOSHE	573
2	3H11	PELICAN LAKE	447
3	3H12	LAKE SAKAKAWEA (GARRISON	445
4	3H03	BRUSH LAKE	342
5	3H10	SWEET BRIAR RESERVOIR	374
6	3H02	LAKE AUDUBON	345
7	3H06	JAMESTOWN RESERVOIR	343
8	3H13	SPIRIT WOOD LAKE	227
9	3B01	LAKE ASHTABULA	204
10	3B0A	MATEJCEK LAKE	200
11	3H15	WHITMAN LAKE	188
12	3H07	LAKE LA MOURE	151
13	3H05	DEVILS LAKE	138
14	3H04	LAKE DARLING	137

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} - acre/feet

Square Kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR NORTH DAKOTA 03/16/76

LAKE CODE 3401 LAKE ASTABULA

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 4946.9

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3801A1	4946.9	1.39	1.53	3.31	13.42	7.70	5.07	2.58	0.93	0.91	0.74	1.22	1.44	3.35
3801A2	3289.3	0.25	0.24	3.65	16.51	5.95	3.37	1.40	0.76	0.59	0.62	0.62	0.40	2.40
3801C1	986.8	0.016	0.014	0.850	2.209	0.481	0.453	0.244	0.096	0.187	0.147	0.133	0.059	0.407
3801Z7	647.5	0.184	0.198	0.425	1.699	0.991	0.651	0.340	0.127	0.113	0.099	0.156	0.184	0.430

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 4946.9
SUM OF SUB-DRAINAGE AREAS = 4923.6

TOTAL FLOW IN = 44.93
TOTAL FLOW OUT = 40.24

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3801A1	9	74	0.371	21	0.340				
	10	74	0.309	20	0.311				
	11	74	0.912	16	1.048				
	12	74	1.475	21	1.557				
	1	75	1.574	18	1.557				
	2	75	1.597	22	1.671				
	3	75	1.934	22	1.614				
	4	75	18.944	5	6.570	19	25.202		
	5	75	23.503	3	44.741	18	21.153		
	6	75	6.428	23	4.729				
	7	75	3.370	19	2.803				
	8	75	1.594	22	0.368				
3801A2	9	74	0.150	21	0.059				
	10	74	0.408	20	0.765				
	11	74	0.991	16	1.076				
	12	74	0.439	21	0.425				
	1	75	0.351	18	0.340				
	2	75	0.399						
	3	75	2.973	22	6.513				
	4	75	20.247	5	6.796	18	22.937		
	5	75	18.972	3	26.816	18	14.725		
	6	75	4.899	23	8.184				
	7	75	2.701	19	2.662				
	8	75	0.507	22	0.232				

LAKE CODE 3R01 LAKE ASTAMULA

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
380161	9	74	0.040	21	0.037				
	10	74	0.074	20	0.071				
	11	74	0.108	16	0.108				
	12	74	0.085	21	0.085				
	1	75	0.045	18	0.034				
	2	75	0.020						
	3	75	0.133	22	0.510				
	4	75	4.219	5	0.116	16	15.291		
	5	75	1.090	3	2.577	14	0.991		
	6	75	0.589	23	0.878				
	7	75	1.019	19	0.566				
	8	75	0.076	22	0.054				
380122	1	0	0.031						
	2	0	0.014						
	3	0	0.091						
	4	0	2.832						
	5	0	0.736						
	6	0	0.396						
	7	0	0.708						
	8	0	0.051						
	9	0	0.028						
	10	0	0.051						
	11	0	0.074						
	12	0	0.057						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/03/16

380101
47 02 12.0 098 04 44.0 3
LAKE ASHTABULA
38003 NORTH DAKOTA

11EPALES 2111202
0027 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/30	09 20	0000	6.0		16	309	7.60	147	0.410	1.900	1.020	0.170
	09 20	0005	6.0	8.8		307	7.60	146	0.350	1.600	0.910	0.161
	09 20	0015	6.0	8.6		306	7.60	147	0.380	1.400	0.930	0.160
	09 20	0023	5.9	8.4		305	7.70	147	0.380	1.500	0.940	0.155
74/07/17	11 20	0000	23.8	5.2	48	702	8.40	256	0.190	1.200	0.100	0.279
	11 20	0005	23.7	5.0		700	8.40	260	0.180	0.900	0.070	0.277
	11 20	0015	23.5	4.8		698	8.40	258	0.190	0.900	0.080	0.307
	11 20	0020	23.4	4.4		699	8.40	244	0.160	1.000	0.080	0.274
74/09/17	14 10	0000	15.0	9.4	49	567	8.79	385	0.040	1.200	0.020K	0.220
	14 10	0015	14.8	9.6		561	8.81	465	0.030	1.100	0.020K	0.204
	14 10	0027	14.6	8.8		565	8.81	425	0.040	1.000	0.020K	0.193

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/30	09 20	0000	0.260	5.4	
	09 20	0005	0.245		
	09 20	0015	0.243		
	09 20	0023	0.239		
74/07/17	11 20	0000	0.283	16.1	
	11 20	0005	0.292		
	11 20	0009			1.0
	11 20	0015	0.326		
	11 20	0020	0.318		
74/09/17	14 10	0000	0.275	17.1	
	14 10	0015	0.245		
	14 10	0027	0.245		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/16

380102
47 04 29.0 098 00 31.0 3
LAKE ASHTABULA
38003 NORTH DAKOTA

11EPALES 2111202
0012 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/30	09 45	0000	11.5		14	266	8.00	106	0.090	1.400	0.620	0.147
	09 45	0008	11.6	10.0		265	7.60	104	0.080	1.200	0.600	0.138
74/07/17	10 30	0000	24.6	6.2	36	729	8.60	250	0.080	1.500	0.060	0.273
	10 30	0005	24.5	6.0		730	8.60	254	0.090	1.200	0.060	0.280
	10 30	0017	24.4	6.0		730	8.60	262	0.100	1.300	0.060	0.281
74/09/17	14 55	0000	15.3	10.4	20	570	8.91	440	0.040	2.100	0.020K	0.088
	14 55	0008	14.5	11.2		571	8.93	435	0.040	2.000	0.020	0.097

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/30	09 45	0000	0.261	21.5	
	09 45	0008	0.247		
74/07/17	10 30	0000	0.377	52.6	
	10 30	0005	0.314		
	10 30	0006			1.0
	10 30	0017	0.319		
74/09/17	14 55	0000	0.224	61.4	
	14 55	0008	0.216		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/16

380103
47 12 48.0 097 57 45.0 3
LAKE ASHTABULA
34009 NORTH DAKOTA

FEMALES 2111202
0022 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/30	10	20 0000	12.0		17	337	8.10	129	0.080	1.200	0.410	0.119
	10	20 0005	11.9	10.2		324	8.10	129	0.060	1.300	0.340	0.117
	10	20 0015	11.6	10.0		322	8.00	124	0.070	1.800	0.400	0.119
74/07/17	10	10 0000	24.7	9.4	36	856	8.40	312	0.040	1.600	0.070	0.304
	10	10 0005	24.5	8.2		847	8.60	324	0.070	1.600	0.070	0.317
	10	10 0016	24.5	8.4		867	8.70	328	0.050	1.600	0.060	0.299
74/09/17	15	15 0000	14.4	10.0	19	633	8.87	455	0.050	3.500	0.020	0.058
	15	15 0005	14.4	10.0		633	8.91	510	0.050	2.600	0.020	0.065
	15	15 0018	14.3	10.0		629	8.91	515	0.060	2.000	0.030	0.074

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/30	10	20 0000	0.237	52.5	
	10	20 0005	0.237		
	10	20 0015	0.236		
74/07/17	10	10 0000	0.477	60.9	
	10	10 0005	0.412		1.0
	10	10 0016	0.395		
74/09/17	15	15 0000	0.202	78.3	
	15	15 0005	0.196		
	15	15 0018	0.197		

STORET RETRIEVAL DATE 76/03/18

380104
47 15 48.0 098 00 39.0 3
LAKE ASHTABULA
38039 NORTH DAKOTA

11EPALES 2111202
0004 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/30	10 40	0000	12.3	8.4	12	442	7.80	163	0.100	1.500	0.220	0.117

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/30	10 40	0000	0.247	38.1	

STORET RETRIEVAL DATE 74/03/15

380105
47 07 45.0 096 02 15.0 3
LAKE ASHTABULA
38003 NORTH DAKOTA

TIEPALES 2111202
0025 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/07/17	10 50	0000	24.3	5.8	36	712	8.60	262	0.100	1.200	0.040	0.273
	10 50	0005	24.2	5.8		712	8.50	246	0.120	1.100	0.050	0.273
	10 50	0015	24.2	5.6		712	8.50	248	0.130	1.200	0.060	0.286
	10 50	0020	24.2	5.6		713	8.50	272	0.140	1.200	0.070	0.278
74/09/17	14 35	0000	15.1	11.4	30	552	8.97	310	0.040	1.400	0.020K	0.117
	14 35	0005	14.3	11.0		545	8.93	470	0.030	1.700	0.020K	0.117
	14 35	0013	14.0	10.4		541	8.95	410	0.040	1.400	0.020	0.112

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/07/17	10 50	0000	0.303	29.2	
	10 50	0005	0.323		
	10 50	0007			1.0
	10 50	0015	0.298		
	10 50	0020	0.306		
74/09/17	14 35	0000	0.212	57.6	
	14 35	0005	0.213		
	14 35	0013	0.286		

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET METHIEVAL DATE 75/03/18

SPOIAI
47 01 55.0 098 05 02.0 4
SHEYENNE RIVER
1804? 7.5 BALD HILL DM
02/LAKE ASHTABULA
BANK SAMPLE 300 FT BELOW BALDHILL DAM
11ERALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/09/21	11 45		0.012	1.000	0.010	0.200	0.240
74/10/20	15 15		0.016	3.500	0.035	0.175	0.320
74/11/18	10 30		0.012	2.100	0.090		0.090
74/12/21	10 10		0.048	1.400	0.270	0.125	0.160
75/01/18	15 30		0.088	2.350	0.552	0.179	0.225
75/02/22	10 45		0.152	2.200	0.697	0.264	0.280
75/03/22	10 40		0.140	2.700	0.630	0.330	0.390
75/04/05	15 25		0.320	2.000	0.390	0.240	0.260
75/04/19	10 55		0.440	1.800	0.145	0.185	0.210
75/05/03	10 35		0.460	1.900	0.240	0.165	0.230
75/05/18	15 25		0.610	1.350	0.145	0.130	0.150
75/06/23	11 10		0.330	2.400	0.180	0.130	0.420
75/07/19	11 20		0.055	1.330	0.330	0.185	0.205
75/08/22	10 40		0.015	2.100	0.075	0.210	0.330

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	01810 NH3-N2 TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/04/21	10	30	0.020	1.300	0.015	0.085	0.135
74/10/20	13	30	0.008	0.400	0.030	0.095	0.120
74/11/15	09	00	0.032	1.250	0.035	0.055	0.080
74/12/21	09	00	0.200	1.100	0.065	0.055	0.080
75/01/14	14	00	0.240	2.000	0.292	0.110	0.120
75/03/22	09	10	0.420	2.400	0.345	0.315	0.470
75/04/05	14	00	0.420	2.200	0.340	0.210	0.250
75/04/14	09	10	1.400	2.600	0.246	0.190	0.400
75/05/03	09	00	0.470	1.450	0.050	0.090	0.230
75/05/14	14	00	0.150	2.000	0.050	0.125	0.140
75/05/23	09	30	0.340	2.500	0.065	0.185	0.420
75/07/14	09	55	0.055	1.750	0.030	0.230	0.300
75/08/22	09	05	0.010	1.700	0.030	0.135	0.280

ST. GET RETRIEVAL DATE 75/03/18

381151
+7 04 03.0 088 05 10.0 4
UNNAMED CREEK
38 [illegible] MILL [illegible]
T/LAKE ASHTABULA
BRDG ON RES RD 1CM 3.2 MI E OF ROSEBERS
11ENGLES 21112[illegible]
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL. MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
75/03/22	10	35	0.440	2.600	0.200	0.345	0.560
75/04/18	10	45	0.860	1.350	0.115	0.250	0.360
75/05/03	10	30	0.030	0.450	0.035	0.120	0.170
75/05/18	15	20	0.010	2.200	0.105	0.300	0.340

SPECIAL
47 11 00.0 084 04 15.0 4
BAL / MILL CREEK
SR 7.5 DAZEY NE
T/CAKE ASHTABULA
SEC RD BRDG 7 MI E OF DAZEY
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/09/21	11	10	0.008	1.700	0.025	0.040	0.150
74/10/20	14	30	0.016	1.200	0.025	0.020	0.070
74/11/16	10	00	0.012	1.000	0.032	0.015	0.040
74/12/21	09	45	0.008	1.300	0.025	0.010	0.030
75/01/18	15	00	0.040	1.100	0.098	0.045	0.070
75/03/22	10	00	0.370	2.000	0.290	0.135	0.250
75/04/05	15	00	0.315	1.400	0.350	0.085	0.130
75/04/18	10	15	1.350	2.600	0.180	0.150	0.390
75/05/03	10	00	0.980	1.350	0.055	0.070	0.160
75/05/18	15	00	0.005	1.140	0.020	0.040	0.040
75/06/23	10	25	0.035	1.800	0.075	0.100	0.150
75/07/14	10	50	0.005	2.300	0.040	0.280	0.370
75/08/22	10	10	0.015	1.500	0.040	0.170	0.270

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO3+NO2 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
74/11/13			0.320	8.000	0.250	0.100	0.300		
74/12/05	15 30		0.320	9.000	0.250	0.500	0.000		
75/01/17	15 00		0.240	22.000	11.500	2.500	10.500		
75/02/19	16 00		2.120	32.000	23.000	5.100	9.400		